COOPERATIVE RESEARCH PROGRAMME NO. 27
TROPICAL ENVIRONMENTAL DATA (TREND)
ECOSYSTEM STUDY OF TROPICAL DRY-EVERGREEN FOREST

sponsored by
ADVANCED RESEARCH PROJECTS AGENCY (ARPA), U.S. DEPARTMENT OF DEFENSE

managed by
EARTH SCIENCES LABORATORY, U.S. ARMY NATICK LABORATORIES (NLABS)

conducted by
APPLIED SCIENTIFIC RESEARCH CORPORATION OF THAILAND

in collaboration with
DEPARTMENT OF METEOROLOGY, OFFICE OF THE PRIME MINISTER
NATIONAL STATISTICAL OFFICE, OFFICE OF THE PRIME MINISTER
ROYAL FOREST DEPARTMENT, MINISTRY OF AGRICULTURE
DEPARTMENT OF RICE, MINISTRY OF AGRICULTURE
DEPARTMENT OF LAND DEVELOPMENT, MINISTRY OF NATIONAL DEVELOPMENT
DEPARTMENT OF MINERAL RESOURCES, MINISTRY OF NATIONAL DEVELOPMENT
CHULALONGKORN UNIVERSITY
KASETSART UNIVERSITY
MILITARY RESEARCH AND DEVELOPMENT CENTER, MINISTRY OF DEFENCE
SEATO MEDICAL RESEARCH LABORATORY

RESEARCH PROJECT NO. 27.
PRIMARY AND SECONDARY
PRODUCTIVITY IN TROPICAL DRY-EVERGREEN FOREST

REPORT NO. 1.
PRIMARY PRODUCTION IN DRY-EVERGREEN FOREST AT SAKAERAT AMPHOE PAK THONG CHAI, CHANGWAT NAKHON RATCHASIMA
I. ESTIMATION OF BIOMASS AND DISTRIBUTION AMONGST VARIOUS ORGANS

SANGA SABHASRI
CHOOB KHEMNARK
SANIT AKSORNKOAE
PADOEM RATISOONTHORN

ASRCT, BANGKOK 1968
not for publication

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F O R E W O R D

This report has been prepared by survey teams from Kasetsart University as a contribution to ASRCT Cooperative Research Programme No. 27: Tropical environmental data (TREND) - Ecosystem study of tropical dry-evergreen forest.

The research is being conducted pursuant to ARPA Order 917 under the management of the Earth Sciences Laboratory, U.S. Army Natick Laboratory (NLABS), Natick, Massachusetts, U.S.A. Dr. Lester W. Trueblood is Director of the Earth Sciences Laboratory. Dr. Paul Dalrymple serves as Project Supervisor, Mr. Frank Barnett as Project Manager, and Mr. George Immisch as Deputy Project Manager.

The research programme is being carried out by the Applied Scientific Research Corporation of Thailand through its Environmental and Ecological Research Institute in collaboration with other agencies of the Thai Government: the Department of Meteorology and the National Statistical Office (Office of the Prime Minister), the Royal Forest Department and the Department of Rice (Ministry of Agriculture), the Department of Land Development and the Department of Mineral Resources (Ministry of National Development), the Chulalongkorn University, the Kasetsart University, and the Military Research and Development Center (Ministry of Defence); and with the SEATO Medical Research Laboratory, Bangkok.

PRIMARY PRODUCTION IN DRY-EVERGREEN FOREST AT SAKAERAT, AMPHOE PAK THONG CHAI, CHANGWAT NAKHON RATCHASIMA

I. ESTIMATION OF BIOMASS AND DISTRIBUTION AMONGST VARIOUS ORGANS

By Sanga Sabhasri,* Choob Khemnark,* Sanit Aksornkoae,* and Padoem Ratisoonthorn+

I. INTRODUCTION

The present investigation is part of an ecosystem study of a dry-evergreen forest at the Sakaerat Experiment Station in Amphoe Pak Thong Chai, Changwat Nakhon Ratchasima in the north-eastern region of Thailand. This report is concerned with an initial examination of the biomass (weight of living plant material), as one step in assessing the primary production in the forest.

Estimates of primary productivity in various habitats throughout the world are of major importance in relation to the global potential for food production. This topic is prominent in the International Biological Programme (IBP) and the present study will form part of Thailand's contribution to IBP.

An accurate and detailed knowledge of the standing crop of a plant community is the necessary biological basis of any attempt to control the productivity of that community. The results of the present investigation will provide a reference framework for evaluating changes that have occurred through disturbance of the vegetation in other parts of the study site or which may be induced in other experiments.

The investigation has also been concerned with establishing correlations between the biomass of a tree and its height and diameter, which can be used in rapid estimations of total biomass and stem volume of an individual tree from the measurement of only one dimension.

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II. PRINCIPLES INVOLVED

Methods of estimating primary production by terrestrial plant communities have been reviewed by Kira et al (1967). These depend on either a harvest technique, in which repeated biomass measurements are made at specific intervals, or a photosynthetic technique, in which the photosynthetic rate of a single leaf is linked with vertical distributions of leaf area and light intensity. Most of the work on this topic has been based on the harvest technique, which was elaborated with special reference to forests by Boysen Tensen (1932).

In essence, harvest methods depend on estimating biomass at the beginning and end of a given period of time, and also the losses by respiration, by death and by grazing and parasitism. Kira et al (1967) concluded that, especially for non-seasonal communities such as tropical forests in which growth ring analysis is difficult, gross production can best be estimated by calculating the increment of biomass derived from repeated estimates of biomass of the same stand, subtracting the losses by litter-fall (measured with litter traps) and by grazing and parasitism (they regard these latter sources as of minor importance) and adding an estimate of community respiration.

The exact estimate of biomass is an especially troublesome task in the study of forest vegetation. Direct measurement by weighing of a reasonably wide area of forest is quite unrealistic and impracticable (Kira and Shidei 1967) and recourse has to be made to relationships between tree weight and other parameters which can be measuring in a large stand (Sabhasri and Wood 1967).

Relationships of this kind, termed allometric relationships, were first formulated by Huxley (1932, cited after Ogino et al. 1964) and Teissier (1934, cited after Ogino et al. 1964) as

$$y = Ax^h \quad \ldots\ldots (1)$$

$$\text{or} \quad \log y = \log A + h \log x \quad \ldots\ldots (2)$$

where y, x are measured quantities of a particular individual and A, h are specific constants.

Kittredge (1944, 1948) was one of the first to apply allometric

relationships to the estimation of forest biomass, making use of a relationship between the weight of leaves and stem diameter. Allometric relations were used by Maruyama and Sata (1953) in estimating foliage and stands in the Akamatsu of Iwate District, Japan. Orington and Madgwich (1959) used such relationships in their studies on the distribution of organic matter and plant nutrients in a plantation of Scotch pines. This technique has been followed in previous work in Thailand by Ogino et al. (1964) in estimating the standing crops in forests in north-eastern Thailand, and by Ogawa et al. (1965) and Ogawa, Yoda, et al. (1965) in studies on three main types of forest vegetation in Thailand, including a stand of dry-evergreen forest near Doi Inthanon in northern Thailand. Ogawa, et al. (1965) reviewed a number of allometric relationships in connection with the data they had collected. Following Shidei (1960, cited after Ogawa et al. 1961), they concluded that there was better correlation between weight of a tree and D^2H (where D is the diameter of the tree at breast height (1.3 m) and H is its height) than between weight and diameter at breast height.

They also concluded that it is reasonable to assume that the allometric relationships between the different measures of a tree is approximately independent of species for tree species of similar life form in the same habitat. They derived (for a sample comprising trees of Dipterocarpus alatus and Pentacine siamensis) the following relationships:

$$W_C = 0.06851\ (D^2H)^{0.8396} \quad \ldots\ldots (3)$$

$$W_L = 0.04518\ (D^2H)^{0.6230} \quad \ldots\ldots (4)$$

where W_C is dry weight of stem and branches in kg,

W_L is dry weight of leaves in kg,

D is diameter at breast height in cm,

H is height in m.

They used these relationships to arrive at biomass for the above mentioned stand of dry-evergreen forest, the total biomass being 290.6 tonnes per hectare, stems and branches of trees contributing 270.9 tonnes per hectare, and leaves of trees 19.5 tonnes per hectare.

Ogawa, Yoda, et al. (1965) and Kira et al. (1967) have used these and other allometric relations in estimating biomass in the forest types already mentioned. In their work they used the following relationships:

$$\frac{1}{H} = \frac{0.543}{D} + 0.0217 \quad \ldots\ldots (5)$$

$$W_S = 0.0396\ (D^2H)^{0.9326} \quad \ldots\ldots (6)$$

$$W_B = 0.006002\ (D^2H)^{1.027} \quad \ldots\ldots (7)$$

$$W_R = 0.0264\ (D^2H)^{0.775} \quad \ldots\ldots (8)$$

$$\frac{1}{W_L} = \frac{13.75}{W_S} + 0.025 \quad \ldots\ldots (9)$$

where W_S, W_B, W_R, W_L are the dry weights of stem, branches, roots, and leaves respectively in kg, and D, H are as before.

III. STUDY MATERIAL

The present investigation was located in the ASRCT Sakaerat Experiment Station situated on Route 304 from Nakhon Ratchasima (Khorat) to Chachoengsao about 60 km south of Nakhon Ratchasima. The stand was in relatively undisturbed dry-evergreen forest, adjacent to the open tower of the micro-meteorological installation, approximately three km southwest of the Station living quarters. The trees were felled during the process of enlarging an existing clearing around the base of the open tower.

The number of species which constitute the stand is large, and more than 100 species were counted including trees, shrubs, climbers and herbage. Details are given in other reports in this series*. The

* "Species composition of dry-evergreen and dry dipterocarp forests at Sakaerat, Pak Thong Chai, Nakhon Ratchasima. I. Variation of floristic composition along a transect through dry-evergreen and dry dipterocarp forests" by Sanga Sabhasri, Ath Boonnitee, Choob Khemmark, and Sanit Aksornkoae. Report No. on Research Project No. 27/1. (ASRCT unpublished report.) "Inventory of vegetation in one hectare (100 m x 100 m plot) centred on forest tower, ASRCT Sakaerat Experiment Station (Amphoe Pak Thong Chai, Changwat Nakhon Ratchasima)" by Tem Smitinand, Chumsri Chaiyanand, Anand Nalamphun, and Thawatchai Santisuk. Report No. 3 on Research Project No. 27/1. (ASRCT unpublished report.)

major species with high frequency of occurrence are: (1) Hopea ferrea Pierre, (2) Hydnocarpus ilicifolius King, (3) Walsura trichostemon Miq., and (4) Memecylon ovatum Sm. Other species of sporadic occurrence have been grouped as "associate species".

Field work was carried out from July to November 1967 during the rainy season and the beginning of the cool season. Details of rainfall, temperature and humidity are given in another report in this series*.

IV. METHOD

A group of trees was selected and measurements were made of various parameters to establish allometric relationships.

The aim in selecting trees was to establish similar numbers within a series of classes based on D^2H (D is diameter at breast height (1.3 m) in cm and H is the height of the tree in m), these classes being chosen to provide an even distribution of class intervals on a logarithmic scale: 0-100, 101-300, 301-500, 501-700, 701-1,000, 1,001-3,000, 3,001-5,000, 5,001-7,000, 7,001-10,000, 10,001-30,000, 30,001-50,000, 50,001-70,000, and 70,001-100,000. Class ranges were determined by first establishing that the volume of a tree approximates the volume of a cylinder (cf. Yoda 1967) with diameter D and height H, which in turn can be directly related to the biomass of the tree.

Diameter was obtained by using a caliper, and height was measured by using a regular metre tape on the felled trees.

Before cutting, each tree was measured at ground level and at 10 cm, 30 cm, and 130 cm above the ground. The purpose of these measurements was to calculate base taper. To obtain the weight of the tree, the stem was cut into 2-m sections, leaves were picked by hand, green and dead branches were removed, and all were weighed and recorded. A common balance scale of 500 kg capacity was mounted on a platform at the tree

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* "Preliminary study of evapotranspiration in dry-evergreen forest at Sakaerat, Amphoe Pak Thong Chai, Changwat Nakhon Ratchasima" by Sanga Sabhasri, Kasem Chunkeo, and Choompol Ngampongsai. Report No. 2 on Research Project No. 27/5 (in preparation).

site for use in the measurements. Weights were recorded to the nearest tenth of a kilogramme. It was determined that the weight of sawdust was not sufficient to merit the difficulty incurred in saving it for weighing.

The following items were measured and recorded for each sample tree:

- H = total height of the tree
- H_C = commercial height or height of the trunk up to the first living branch
- D_{00} = diameter at ground level
- D_{10} = diameter at 10 cm above ground level
- $D_{1.3}$ = diameter at 1.3 m above ground level, which is analogous to diameter at breast height (DBH)
- D_2 = diameter at 2 m above ground level, and from this height upward, diameter at the height of every 2 m to the tip
- C = crown length
- W_S = green weight, being the sum of the weights of every 2-m log
- W_B = weight of green branches
- W_L = weight of green leaves
- W_T = total weight of green stem, branches, and leaves.

Heights and crown length were recorded in metres, diameters in centimetres, and weights in kilogrammes.

Samples of stems, branches, and leaves were collected and dried in an oven at 105°C for 24 hours to determine moisture content, and these values were then used to correct the green weights to oven-dry weights, the latter being represented by W_S, W_B, W_L, W_T for stem weight, weight of branches, weight of leaves and total weight respectively. The stem volume of each tree was calculated by using Smalian's formula (Bruce & Schumacher 1950): The number of trees in each D^2H class for each species is shown in Table 1.

From these measurements allometric relationships were calculated

TABLE 1

NUMBER OF TREES CUT IN EACH SPECIES

D^2H class	Hopea ferrea	Hydnocarpus illicifolius	Walsura trichostemon	Memecylon ovatum	Others	Total
1 - 100	8	7	6	4	5	30
101 - 300	4	4	15	8	7	38
301 - 500	5	5	6	1	-	17
501 - 700	4	4	4	1	2	15
701 - 1000	5	3	5	4	-	17
1001 - 3000	8	11	8	3	9	39
3001 - 5000	4	2	-	-	5	11
5001 - 7000	4	-	-	1	3	8
7001 - 10000	5	2	-	-	2	9
10001 - 30000	12	4	-	-	5	21
30001 - 50000	5	4	-	-	-	5
50001 - 70000	2	-	-	-	-	2
70001 - 100000	2	-	-	-	-	2
Total	68	42	44	22	38	214

Rewriting equation (2) with y = W (total weight) and x + D^2H, the equation becomes

$$\log W = \log A + h \log (D^2H) \quad \ldots\ldots (10)$$

For a series of trees this becomes

$$\Sigma \log W = \Sigma \log A + h \ \Sigma \log (D^2H) \quad \ldots\ldots (11)$$

and $$\Sigma(D^2H) \log W = \Sigma(D^2H) \log A + h \ \Sigma(D^2H) \log (D^2H) \ .. (12)$$

The constants log A and h can be calculated from these formulae, and in this way regression equations for weight against D^2H, weight against D, and volume against D^2H were obtained. Samples of the calculation are given in the Appendix. The values were used to prepare graphs for each relationship.

For the study of biomass per unit area, a sample plot of 20 m x 20 m was laid out and the following items were measured and recorded:

(1) Tree species of more than 4 m in height were recorded and measured as mentioned above.

(2) The undergrowth including trees less than 4 m in height, shrubs, herbs, and grasses was cleaned from the plot, and the stems and branches were separated from the leaves and weighed.

(3) Climbers were collected and weighed.

Samples of all material were collected and oven-dried to determine moisture content, and these values were used to correct the green weights to oven-dry weights.

The weight and volume of the standing crop was then determined using the specific values of allometric relationships arrived at from the earlier sets of measurements.

The value of D^2H was calculated for each tree and the weight or volume determined using the graphs of appropriate allometric relationships. Where particular relationships had been determined for the species, these were used, otherwise the relationships for "all species" was used.

In those cases where it was difficult to measure tree height and this occurred often in this dense stand where the top of a tree could

hardly be seen from a distance the relationships connecting D with weight or volume were used.

V. RESULTS AND DISCUSSION

Table 2 summarizes the data for the 214 trees in the selected group of trees. The four major species already mentioned were the only ones which occurred frequently enough to be included in more than six D^2H classes. Data for all trees measured are averaged in the summary under the heading "all species".

Table 3 regroups the data under D^2H classes, information being given in each class for the individual species in the sample.

Figures 1 to 7 display the allometric relationships as follows:

(1) Total green weight (W_T) against D^2H.

(2) Total dry weight (w_T) against D^2H.

(3) Stem weight (w_S) against D^2H.

(4) Weight of branches (w_B) against D^2H.

(5) Weight of leaves (w_L) against D^2H.

(6) Stem volume against D^2H.

(7) Total dry weight (w_T) against DH.

In each case the relationships are given for each of the four major species and for all of the species taken together. This information is restated in Tables 4 to 9. Here b is the slope of the regression line and log A is the value of y when x = 1. The values of r^2, the coefficient of determination, indicates that the regression equations for the relationships involving D^2H are undoubtedly strong.

Table 10 summarizes data for the 20 m x 20 m plot showing the contributions of the various parts of the tree to total weight (green and oven-dry), and also the stem volume, for the 14 tree species above 4 m high and for the undergrowth and climbers.

Table 11 gives more detailed information for all the plants in the plot.

TABLE 2

SUMMARY OF AVERAGED VALUES OF HEIGHT AND WEIGHT DATA FOR FOUR MAJOR AND ALL SPECIES BY D^2H CLASSES

D^2H class	No. of trees	Averaged actual D^2H	Species	DBH (cm)	Height (m)			Green weight (kg)				Oven-dry weight (kg)				Stem vol. (m^3)
					First branch	Crown length	Total	Stem	Branches	Leaves	Total	Stem	Branches	Leaves	Total	
1 - 100	8	54.614		3.00	2.75	2.96	5.71	4.21	1.11	0.89	6.21	2.86	0.67	0.41	3.94	0.00330
101 - 300	4	170.927		4.95	4.00	3.20	7.20	13.68	3.53	1.38	18.59	9.33	2.12	0.64	12.09	0.00972
301 - 500	5	413.379		6.38	6.00	4.08	10.08	26.04	5.08	2.54	33.66	17.76	3.05	1.18	21.99	0.02040
501 - 700	4	569.392		7.12	5.75	5.46	11.21	32.93	7.20	2.23	42.36	22.46	4.33	1.04	27.83	0.02568
701 - 1000	5	824.834		8.62	5.80	5.28	11.08	46.84	11.96	5.04	63.84	32.79	7.72	2.33	42.84	0.03733
1001 - 3000	8	1797.760		10.81	6.88	6.61	13.49	78.35	23.48	4.60	106.43	54.85	15.16	2.13	72.14	0.06734
3001 - 5000	4	4270.673	*Hopea ferrea*	15.48	7.75	10.05	17.80	239.33	68.85	14.00	322.18	167.53	44.48	6.48	218.49	0.18755
5001 - 7000	4	5906.937		18.02	9.25	8.95	18.20	331.65	106.63	19.40	457.68	232.16	68.88	8.98	310.02	0.27377
7001 - 10000	5	8274.773		21.38	8.80	9.31	18.11	428.10	193.52	38.70	660.32	317.65	110.89	20.47	449.01	0.37363
10001 - 30000	12	17546.502		28.42	10.75	10.52	21.27	826.49	318.78	30.36	1175.63	613.26	190.85	16.06	820.17	0.75893
30001 - 50000	5	35531.992		38.36	12.00	12.28	24.28	1646.02	679.32	44.20	2369.54	1221.34	389.25	23.38	1633.97	1.39651
50001 - 70000	2	58241.986		47.33	12.00	14.10	26.10	2583.85	1024.70	89.20	3697.75	1974.07	621.99	36.84	2632.90	2.32933
70001 - 100000	2	77008.500		55.50	10.00	15.00	25.00	2848.80	2961.05	232.75	6042.60	2176.48	1797.36	102.03	4075.87	2.64669
1 - 100	6	53.189		3.00	3.17	2.18	5.35	3.98	0.56	0.50	5.04	2.69	0.31	0.23	3.23	0.00343
101 - 300	15	198.314		5.08	3.75	3.76	7.51	13.11	3.38	1.93	18.42	8.86	1.92	0.87	11.65	0.01083
301 - 500	6	295.440		6.63	5.07	3.69	8.76	25.88	20.65	7.97	54.50	17.33	11.73	3.61	32.67	0.02003
501 - 700	4	603.300		7.5	7.00	3.12	10.12	41.12	10.10	3.12	54.34	27.80	5.51	1.41	34.72	0.03707
701 - 1000	5	899.537	*Walsura trichostemon*	8.6	7.40	4.72	12.12	59.90	11.80	4.62	76.32	38.42	7.03	2.31	47.76	0.05168
1001 - 3000	8	1735.625		11.9	6.37	5.65	12.02	103.05	36.11	7.82	146.98	76.31	24.74	3.55	104.60	0.10060

TABLE 2 (continued)

D^2H class	No. of trees	Averaged actual D^2H	Species	DBH (cm)	Height (m)			Green weight (kg)				Oven-dry weight (kg)				Stem vol. (m^3)
					First branch	Crown length	Total	Stem	Branches	Leaves	Total	Stem	Branches	Leaves	Total	
1 - 100	4	41.724	*Memecylon ovatum*	2.80	2.90	1.71	4.61	2.90	0.58	0.65	4.13	1.96	0.38	0.29	2.63	0.00267
101 - 300	8	225.730		5.63	4.37	2.79	7.16	13.06	3.37	2.57	19.00	8.78	2.24	1.17	12.19	0.01105
301 - 500	1	423.729		6.90	6.00	2.90	8.90	22.40	5.00	5.00	32.40	15.05	3.32	2.27	20.64	0.02090
501 - 700	1	580.926		7.30	4.00	5.40	9.40	34.40	12.10	7.80	54.30	23.12	8.03	3.54	34.69	0.02722
701 - 1000	4	810.913		8.95	6.00	4.20	10.20	49.18	20.20	7.12	76.50	33.03	13.28	3.23	49.54	0.03813
1001 - 3000	3	1535.215		10.80	8.00	4.40	12.40	93.57	19.80	6.97	120.34	62.88	13.15	3.16	79.09	0.07253
3001 - 5000	-	-		-	-	-	-	—	-	-	-	-	-	-	-	-
5001 - 7000	1	5180.300		19.10	8.00	6.20	14.20	303.00	84.60	21.3	408.90	203.62	56.17	9.67	269.46	0.23438
1 - 100	7	59.082	*Hydnocarpus ilicifolius*	2.90	4.00	2.29	6.29	4.67	0.67	0.63	5.97	2.96	0.39	0.24	3.59	0.00321
101 - 300	4	180.834		4.90	5.25	2.48	7.23	12.50	2.78	1.22	16.50	7.91	1.65	0.47	10.03	0.01065
301 - 500	5	371.231		6.52	5.20	3.60	8.80	20.76	7.26	2.92	30.84	13.14	4.31	1.12	18.57	0.01770
501 - 700	4	570.155		7.42	6.00	4.40	10.40	36.20	10.58	3.20	49.98	22.91	6.27	1.22	30.40	0.02672
701 - 1000	3	847.789		8.30	6.00	6.40	12.40	46.27	11.96	4.56	62.79	29.29	7.09	1.74	38.12	0.03325
1001 - 3000	11	2217.719		12.97	6.82	6.16	12.98	115.87	30.73	8.11	154.71	73.76	18.23	3.98	95.97	0.09502
3001 - 5000	2	4113.709		17.75	9.00	4.10	13.10	230.40	29.10	5.45	264.95	145.84	17.26	2.08	165.18	0.20263
5001 - 7000	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-
7001 - 10000	2	8020.933		23.45	6.00	8.67	14.67	444.70	128.65	11.85	585.20	281.50	76.29	4.52	362.31	0.37080
10001 - 30000	4	16515.368		29.12	7.00	11.48	18.48	607.28	196.72	17.20	821.20	384.41	116.66	6.57	507.64	0.56246

TABLE 2 (continued)

D^2H class	No. of trees	Averaged actual D^2H	Species	DBH (cm)	Height (m)			Green weight (kg)				Oven-dry weight (kg)				Stem vol. (m^3)
					First branch	Crown length	Total	Stem	Branches	Leaves	Total	Stem	Branches	Leaves	Total	
1 - 100	30	39.333		3.18	3.31	2.35	5.66	4.64	1.26	0.83	6.73	3.02	0.73	0.38	4.23	0.00564
101 - 300	38	195.803		5.21	4.67	2.52	7.19	12.65	2.41	1.40	16.37	8.16	1.35	0.61	10.12	0.01084
301 - 500	17	331.027		5.29	4.45	2.85	7.30	19.01	7.60	3.69	30.30	12.66	4.48	1.64	18.78	0.01581
501 - 700	15	570.734		7.32	5.79	4.76	10.56	35.14	8.40	3.78	47.31	23.74	5.11	1.65	30.49	0.02777
701 - 1000	17	845.791		8.61	6.30	5.15	11.45	50.55	13.98	5.34	69.86	33.36	8.78	2.40	44.57	0.04010
1001 - 3000	39	1644.031	All spp.	11.19	7.24	5.41	12.62	87.86	29.28	8.11	125.25	55.79	17.40	3.73	76.92	0.05789
3001 - 5000	11	3949.417		15.93	10.71	5.62	15.73	206.42	40.51	7.51	254.43	134.93	23.29	3.31	161.53	0.18065
5001 - 7000	8	6068.205		20.26	8.45	6.49	14.94	357.67	108.43	16.42	482.52	247.18	66.58	7.71	321.47	0.29398
7001 - 10000	9	8621.421		22.21	9.20	8.40	17.60	447.28	154.64	22.96	624.88	297.82	91.92	10.55	400.29	0.37476
10001 - 30000	21	13929.959		26.86	10.25	8.86	19.11	552.97	211.69	24.12	788.78	373.95	123.52	11.07	508.54	0.51459
30001 - 50000	5	35531.992		38.36	12.00	12.28	24.28	1646.02	679.32	44.20	2369.54	1221.34	389.25	23.38	1633.97	1.39651
50001 - 70000	2	58241.986		47.33	12.00	14.10	26.10	2583.85	1024.70	89.20	3697.75	1974.07	621.99	36.84	2632.90	2.32933
70001 - 100000	2	77008.500		55.50	10.00	15.00	25.00	2848.80	2961.05	232.75	6042.60	2176.48	1797.36	102.03	4075.87	2.64669

TABLE 3

SUMMARY OF HEIGHT AND WEIGHT DATA FOR ALL SPECIES BY D^2H CLASSES

D^2H class	Tree no.	Actual D^2H	Species	DBH (cm)	Height (m)			Green weight (kg)				Oven-dry weight (kg)				Stem volume (m^3)
					First branch	Crown length	Total	Stem	Branches	Leaves	Total	Stem	Branches	Leaves	Total	
1 - 100	Av. of 8	54.614	Hopea ferrea	3.00	2.75	2.96	5.71	4.21	1.11	0.89	6.21	2.86	0.67	0.41	3.94	0.00330
	Av. of 6	53.189	Walsura trichostemon	3.00	3.17	2.18	5.35	3.98	0.56	0.50	5.04	2.69	0.31	0.23	3.23	0.00343
	Av. of 4	41.724	Memecylon ovatum	2.80	2.90	1.71	4.61	2.90	0.58	0.65	4.13	1.96	0.38	0.29	2.63	0.00267
	Av. of 7	59.082	Hydnocarpus ilicifolia	2.90	4.00	2.29	6.29	4.67	0.67	0.63	5.97	2.96	0.39	0.24	3.59	0.00321
	83	57.136	Memecylon sp.	3.60	2.00	2.10	4.10	5.00	2.20	1.90	9.10	3.32	1.37	0.98	5.67	0.00393
	94	72.704	Memecylon sp.	3.20	4.00	3.10	7.10	5.60	1.90	0.80	8.30	3.72	1.20	0.40	4.30	0.00444
	74	33.408	Casearia grewiifolia	2.40	4.00	1.80	5.80	2.10	0.40	0.50	3.00	1.27	0.20	0.18	1.65	0.00222
	89	96.000	Casearia grewiifolia	4.00	5.00	1.00	6.00	6.40	2.20	0.80	9.40	3.88	1.13	0.28	5.29	0.00541
	91	82.140	Aglaia sp.	3.70	2.00	4.00	6.00	6.90	1.70	0.80	9.40	4.55	0.94	0.38	5.87	0.00434
	Total	353.997		28.60	29.82	21.14	50.96	41.76	11.32	7.47	60.55	27.21	6.59	3.39	37.96	0.03295
	Mean	39.333		3.18	3.31	2.35	5.66	4.64	1.26	0.83	6.73	3.02	0.73	0.38	4.23	0.00366
101 - 300	Av. of 4	170.927	Hopea ferrea	4.95	4.00	3.20	7.20	13.68	3.53	1.38	18.59	9.33	2.12	0.64	12.09	0.00972
	Av. of 15	198.314	Walsura trichostemon	5.08	3.75	3.76	7.51	13.11	3.38	1.93	18.42	8.86	1.92	0.87	11.65	0.01083
	Av. of 8	225.730	Memecylon ovatum	5.63	4.37	2.79	7.16	13.06	3.37	2.57	19.00	8.78	2.24	1.17	12.19	0.01105

TABLE 3 (continued)

D^2H class	Tree no.	Actual D^2H	Species	DBH (cm)	Height (m)			Green weight (kg)				Oven-dry weight (kg)				Stem volume (m^3)
					First branch	Crown length	Total	Stem	Branches	Leaves	Total	Stem	Branches	Leaves	Total	
101 - 300	98	226.796	Unidentified	6.20	4.00	1.90	5.90	15.00	1.40	1.40	17.80	9.53	0.76	0.68	10.97	0.01409
	64	152.776	Unidentified	5.20	4.00	1.65	5.65	10.20	1.70	1.20	13.10	6.48	0.97	0.48	7.93	0.00751
	61	172.500	Siphonodon celastrineus	5.00	4.00	2.90	6.90	10.10	2.00	1.30	13.40	6.34	1.07	0.49	7.90	0.01043
	102	123.480	Melodorum sp.	4.20	4.00	3.00	7.00	6.50	0.60	0.30	7.40	4.42	0.36	0.15	4.93	0.00563
	88	154.880	Casearia grewiifolia	4.40	6.00	2.00	8.00	12.00	3.20	1.80	17.00	7.27	1.64	0.63	8.91	0.00860
	212	297.680	Siphonodon celastrineus	6.10	6.00	2.00	8.00	16.80	1.90	1.10	18.80	10.55	1.01	0.42	11.98	0.01703
	204	259.920	Grewia paniculata	5.70	6.00	2.00	8.00	16.20	2.70	1.20	20.10	10.30	1.16	0.47	11.93	0.01366
	Total	2153.837		57.36	51.37	27.68	79.05	139.15	26.56	15.40	180.11	89.77	14.90	6.74	111.41	0.11920
	Mean	195.803		5.21	4.67	2.52	7.19	12.65	2.41	1.40	16.37	8.16	1.35	0.61	10.12	0.01084
301 - 500	Av. of 5	413.379	Hopea ferrea	6.38	6.00	4.08	10.08	26.04	5.08	2.54	33.66	17.76	3.05	1.18	21.99	0.02040
	Av. of 6	446.796	Walsura trichostemon	6.63	5.07	3.69	8.76	25.88	20.65	7.97	54.50	17.33	11.73	3.61	32.67	0.02005
	171	423.729	Memecylon ovatum	6.90	6.00	2.90	8.90	22.40	5.00	5.00	32.40	15.05	3.32	2.27	20.64	0.02090
	Av. of 5	371.231	Hydnocarpus ilicifolius	6.52	5.20	3.60	8.80	20.76	7.26	2.92	30.84	13.14	4.31	1.12	18.57	0.01770
	Total	1655.135		26.43	22.27	14.27	36.54	95.08	37.99	18.43	151.50	63.28	22.41	8.18	93.87	0.07903
	Mean	331.027		5.29	4.45	2.85	7.30	19.01	7.60	3.69	30.30	12.66	4.48	1.64	18.78	0.01581

TABLE 3 (continued)

D^2H class	Tree no.	Actual D^2H	Species	DBH (cm)	Height (m)			Green weight (kg)				Oven-dry weight (kg)				Stem volume (m^3)
					First branch	Crown length	Total	Stem	Branches	Leaves	Total	Stem	Branches	Leaves	Total	
501 - 700	Av. of 4	569.392	Hopea ferrea	7.12	5.75	5.46	11.21	32.93	7.20	2.23	42.36	22.46	4.33	1.04	27.83	0.02568
	Av. of 4	603.300	Walsura trichostemon	7.50	7.00	3.12	10.12	41.12	10.10	3.12	54.34	27.80	5.51	1.41	34.72	0.03707
	159	500.926	Memecylon ovatum	7.30	4.00	5.40	9.40	34.40	12.10	7.80	54.30	23.12	8.03	3.54	34.69	0.02722
	Av. of 4	570.155	Hydnocarpus ilicifolius	7.42	6.00	4.40	10.40	36.20	10.58	3.20	49.98	22.91	6.27	1.22	30.40	0.02672
	76	622.080	Memecylon ovatum	7.20	6.00	6.00	12.00	35.40	4.10	1.90	41.40	22.97	2.42	0.60	25.99	0.02425
	127	558.552	Agalaia sp.	7.40	6.00	4.20	10.20	30.80	6.30	4.40	41.50	23.16	4.07	2.06	29.29	0.02568
	Total	3424.405		43.94	34.75	28.58	63.33	210.85	50.38	22.65	283.88	142.42	30.63	9.87	182.92	0.16663
	Mean	570.734		7.32	5.79	4.76	10.56	35.14	8.40	3.78	47.31	23.74	5.11	1.65	30.49	0.02777
701 - 1000	Av. of 5	824.834	Hopea ferrea	8.62	5.80	5.28	11.08	46.84	11.96	5.04	63.84	32.79	7.72	2.33	42.84	0.03733
	Av. of 5	899.537	Walsura trichostemon	8.60	7.40	4.72	12.12	59.90	11.80	4.62	76.32	38.42	7.03	2.31	47.76	0.05168
	Av. of 4	810.913	Memecylon ovatum	8.93	6.00	4.20	10.20	49.18	20.20	7.12	76.50	33.03	13.28	3.23	49.54	0.03813
	Av. of 3	847.789	Hydnocarpus ilicifolius	8.30	6.00	6.40	12.40	46.27	11.96	4.56	62.79	29.29	7.09	1.74	38.12	0.03325
	Total	3383.163		34.45	25.20	20.60	45.80	202.19	55.92	21.34	279.45	133.44	35.12	9.61	178.26	0.16039
	Mean	845.791		8.61	6.30	5.15	11.45	50.55	13.98	5.34	69.86	33.36	8.78	2.40	44.57	0.04010

TABLE 3 (continued)

D^2H class	Tree no.	Actual D^2H	Species	DBH (cm)	Height (m)			Green weight (kg)				Oven-dry weight (kg)				Stem volume (m^3)
					First branch	Crown length	Total	Stem	Branches	Leaves	Total	Stem	Branches	Leaves	Total	
1001 - 3000	Av. of 8	1797.760	Hopea ferrea	10.81	6.88	6.61	13.49	78.35	23.48	4.60	106.43	54.85	15.16	2.13	72.14	0.06734
	Av. of 8	1735.625	Walsura trichostemon	11.90	6.37	5.65	12.02	103.05	36.11	7.82	146.98	76.31	24.74	3.55	104.60	0.10060
	Av. of 3	1535.215	Memecylon ovatum	10.80	8.00	4.40	12.40	93.57	19.80	6.97	120.34	62.88	13.15	3.16	79.09	0.07253
	Av. of 11	2217.719	Hydnocarpus ilicifolius	12.97	6.82	6.16	12.71	115.87	30.73	8.11	154.71	73.76	18.23	3.98	95.97	0.09502
	63	1238.916	Casearia grewiifolia	9.80	6.00	6.90	12.90	59.10	40.60	14.70	114.40	35.81	20.79	5.17	61.77	0.05041
	58	1492.992	Melodorum sp.	10.80	6.00	6.80	12.80	70.60	20.30	6.40	97.30	48.01	12.10	3.12	63.23	0.07035
	85	1360.000	Siphonodon celastrineus	10.00	8.00	5.60	13.60	59.20	11.50	6.80	77.50	37.18	6.14	2.58	45.90	0.04997
	209	1595.869	Diospyros sp.	12.10	8.00	2.90	10.90	63.80	10.30	1.60	75.70	6.65	5.08	0.73	12.46	0.06090
	221	2902.500	Xerospermum intermedium	15.00	6.00	6.90	12.90	161.50	112.80	27.70	302.00	112.89	70.39	14.32	197.60	0.13494
	222	2053.345	Unidentified	11.90	8.00	6.50	14.50	117.00	42.20	11.50	170.70	80.96	23.34	6.29	110.59	0.11086
	224	1230.000	Antidesma ghaesembilla	10.00	8.00	4.30	12.30	84.10	16.30	3.70	104.10	53.49	8.35	1.54	63.38	0.05770
	226	1170.432	Croton sp.	9.60	8.00	4.70	12.70	52.20	4.00	2.00	58.20	29.75	2.03	0.63	32.41	0.05239
	225	1042.034	Siphonodon celastrineus	9.80	8.00	2.85	10.85	83.90	12.50	3.50	99.90	52.69	6.68	1.33	60.70	0.06354
	Total	21372.407		145.48	94.07	70.27	164.07	1142.22	380.62	105.40	1628.24	725.23	226.18	48.53	999.94	0.98655
	Mean	1644.031		11.19	7.24	5.41	12.62	87.86	29.28	8.11	125.25	55.79	17.40	3.73	76.92	0.05789

TABLE 3 (continued)

D^2H class	Tree no.	Actual D^2H	Species	DBH (cm)	Height (m)			Green weight (kg)				Oven-dry weight (kg)				Stem volume (m^3)
					First branch	Crown length	Total	Stem	Branches	Leaves	Total	Stem	Branches	Leaves	Total	
3001 - 5000	Av. of 4	4278.673	Hopea ferrea	15.48	7.75	10.05	17.80	239.33	68.85	14.00	322.18	167.53	44.48	6.48	218.49	0.18755
	Av. of 2	4113.709	Hydnocarpus ilicifolius	17.75	9.00	4.10	13.10	230.40	29.10	5.45	264.95	145.84	17.26	2.08	165.18	0.20263
	79	3775.172	Aglaia sp.	16.60	8.00	5.70	13.70	219.10	61.30	8.60	253.90	164.76	39.60	4.02	208.38	0.17515
	108	3240.032	Unidentified	14.60	10.00	5.20	15.20	192.50	9.10	4.20	205.80	97.60	5.66	2.07	105.33	0.14816
	100	4147.200	Shorea seri-ceiflora	14.40	16.00	4.00	20.00	217.00	9.20	2.80	229.00	149.80	5.28	1.77	156.85	0.20118
	216	4007.504	Siphonodon celastrineus	16.40	10.00	4.90	14.90	184.10	50.50	10.00	244.60	115.61	26.97	3.79	146.37	0.16800
	220	4091.626	Grewia pani-culata	16.30	10.00	5.40	15.40	162.50	55.50	7.50	225.50	103.35	23.81	2.93	130.09	0.18190
	Total	27645.916		111.53	70.75	39.35	110.10	1444.93	283.55	52.55	1781.03	944.49	163.06	23.14	1130.69	1.26457
	Mean	3949.417		15.93	10.71	5.62	15.73	206.42	40.51	7.51	254.43	134.93	23.29	3.31	161.53	0.18065
5001 - 7000	Av. of 4	5906.937	Hopea ferrea	18.02	9.25	8.95	18.20	331.65	106.63	19.40	457.68	232.16	68.88	8.98	310.02	0.27377
	202	5180.300	Memecylon ovatum	19.10	8.00	6.20	14.20	303.00	84.60	21.30	408.90	203.62	56.17	9.67	269.46	0.23438
	109	6492.708	Xerospermum intermedium	20.60	10.00	5.30	15.30	376.00	112.90	12.10	501.00	262.82	70.45	6.26	339.53	0.32137
	131	6844.500	Agalaia sp.	23.40	7.00	5.50	12.50	445.70	130.80	19.20	595.70	335.17	84.50	8.99	428.66	0.35581
	223	5916.580	Diospyros sp.	20.20	8.00	6.50	14.50	331.40	107.20	10.10	448.70	202.15	52.90	4.63	259.68	0.28459
	Total	30341.025		101.32	42.25	32.45	74.70	1788.35	542.13	82.10	2412.58	1235.92	332.90	38.53	1607.35	1.46992
	Mean	6068.205		20.26	8.45	6.49	14.94	357.67	108.43	16.42	482.52	247.18	66.58	7.71	321.47	0.29398

TABLE 3 (continued)

D^2H class	Tree no.	Actual D^2H	Species	DBH (cm)	Height (m)			Green weight (kg)				Oven-dry weight (kg)				Stem volume (m^3)
					First branch	Crown length	Total	Stem	Branches	Leaves	Total	Stem	Branches	Leaves	Total	
7001 - 10000	Av. of 5	8274.773	Hopea ferrea	21.38	8.80	9.31	18.11	428.10	193.52	38.70	660.32	317.65	110.89	20.47	449.01	0.37363
	Av. of 2	8020.933	Hydnocarpus ilicifolius	23.45	6.00	8.67	14.67	444.70	128.65	11.85	585.20	281.50	76.29	4.52	362.31	0.37080
	117	9496.278	Siphonodon celastrineus	21.90	14.00	5.80	19.80	453.00	69.80	19.19	541.90	284.48	37.27	7.24	328.99	0.35237
	101	8693.698	Memecylon sp.	22.10	8.00	9.80	17.80	463.30	226.60	22.20	712.10	307.63	143.21	9.97	460.81	0.40222
	Total	34485.682		88.83	36.80	33.58	70.38	1789.10	618.57	91.85	2499.57	1191.26	367.66	42.20	1601.62	1.49902
	Mean	8621.421		22.21	9.20	8.40	17.60	447.28	154.64	22.96	624.88	297.82	91.92	10.55	400.29	0.37476
10001 - 30000	Av. of 12	17546.502	Hopea ferrea	28.42	10.75	10.52	21.27	826.49	318.78	30.36	1175.63	613.26	190.85	16.06	820.17	0.75893
	Av. of 4	10515.368	Hydnocarpus ilicifolius	29.12	7.00	11.48	18.47	607.28	196.72	17.20	821.20	384.41	116.66	6.57	507.64	0.56246
	146	12582.912	Memecylon sp.	25.60	10.00	9.20	19.20	475.80	142.60	24.60	643.00	315.93	90.12	12.28	418.33	0.41907
	227	10629.952	Memecylon sp.	26.80	4.00	10.80	14.80	329.70	294.50	34.90	659.10	213.98	174.05	10.96	398.99	0.31375
	42	13758.417	Shorea ceri-ceiflora	24.30	18.00	5.30	23.30	652.30	105.10	12.10	769.50	448.13	60.33	7.66	516.12	0.61393
	207	16040.808	Diospyros sp.	30.90	10.00	6.80	16.80	477.60	244.70	29.60	751.90	291.34	120.64	13.56	425.54	0.53565
	219	10435.759	Xerospermum intermedium	22.90	12.00	7.90	19.90	501.60	179.50	20.10	701.20	350.62	112.01	10.39	473.02	0.39831
	Total	97509.718		188.04	71.74	62.00	133.74	3870.77	1481.85	168.86	5521.48	2617.67	864.66	77.48	3559.81	3.60210
	Mean	13929.959		26.86	10.25	8.86	19.11	552.97	211.69	24.12	788.78	373.95	123.52	11.07	508.54	0.51459

TABLE 3 (continued)

D^2H class	Tree no.	Actual D^2H	Species	DBH (cm)	Height (m)			Green weight (kg)				Oven-dry weight (kg)				Stem volume (m^3)
					First branch	Crown length	Total	Stem	Branches	Leaves	Total	Stem	Branches	Leaves	Total	
30001 - 50000	Av. of 5	35531.992	Hopea ferrea	38.36	12.00	12.28	24.28	1646.02	679.32	44.20	2369.54	1221.34	389.25	23.38	1633.97	1.39651
50001 - 70000	Av. of 2	58241.986	Hopea ferrea	47.33	12.00	14.10	26.10	2583.85	1024.70	89.20	3697.75	1974.07	621.99	36.84	2632.90	2.32933
70001 - 100000	Av. of 2	77008.500	Hopea ferrea	55.50	10.00	15.00	25.00	2848.80	2961.05	232.75	6042.60	2176.48	1797.36	102.03	4075.87	2.64669

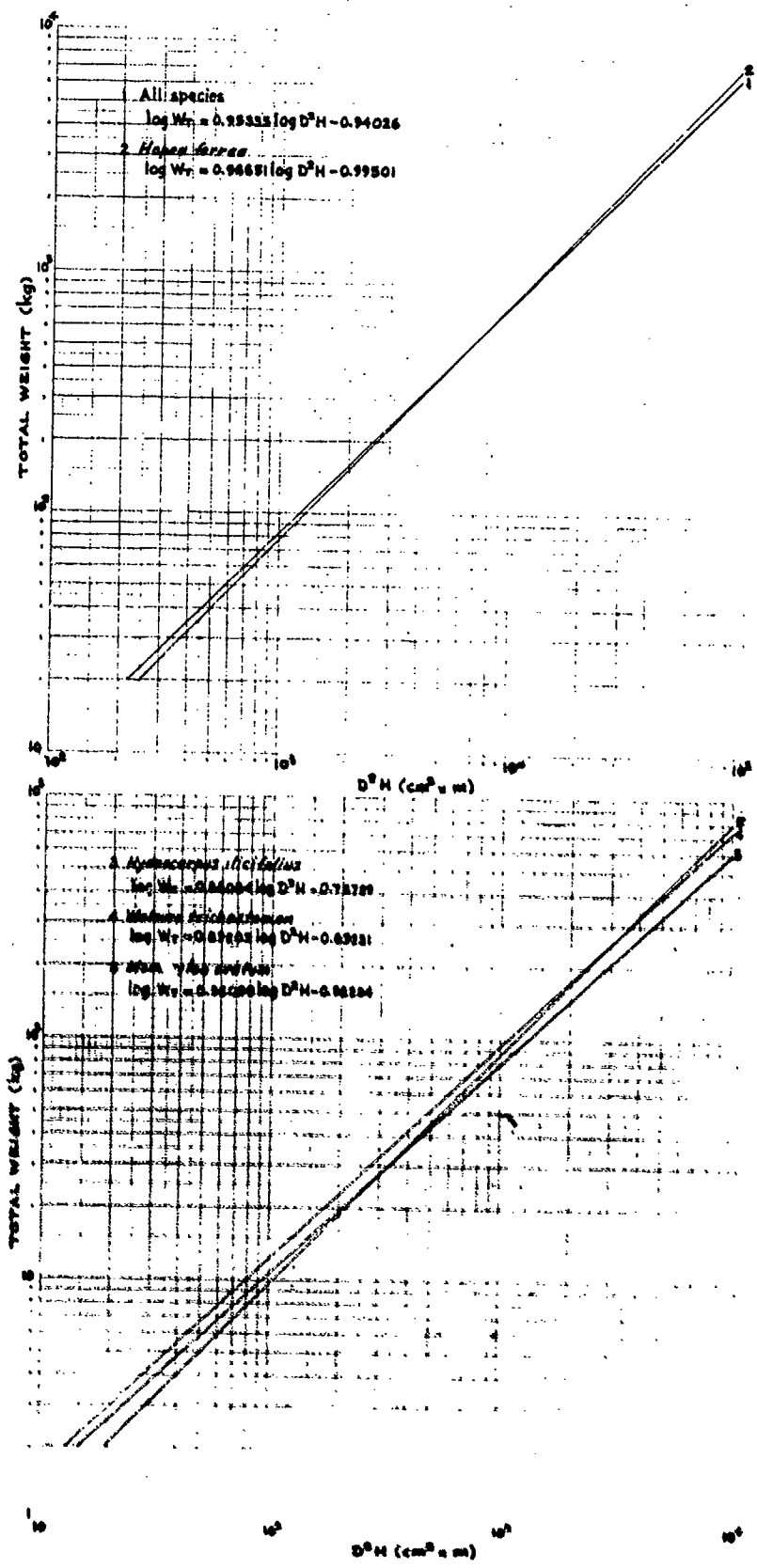

Figure 1. Allometric relation between total green weight and D^2H.

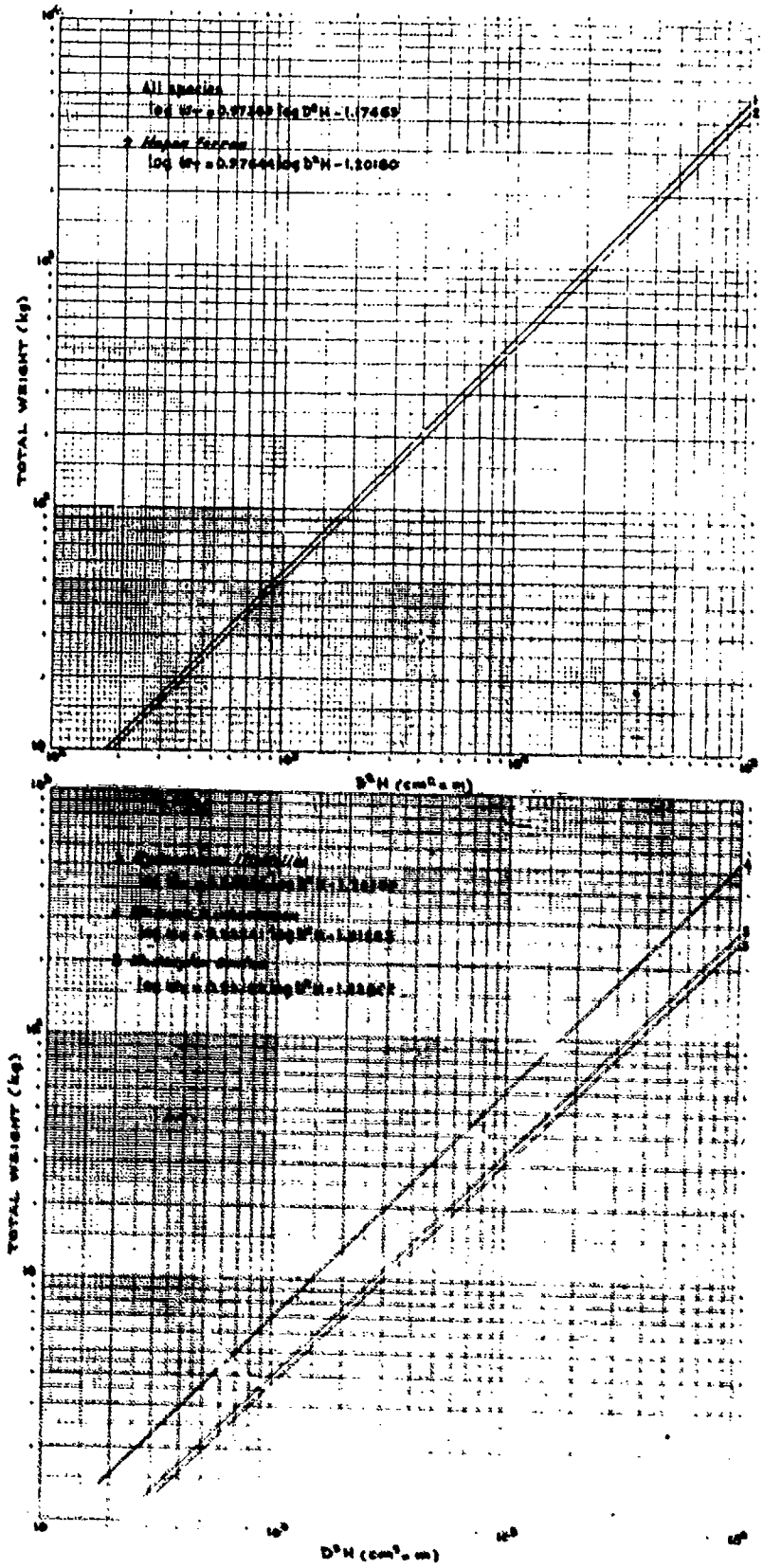

Figure 2. Allometric relation between total dry weight and D^2H.

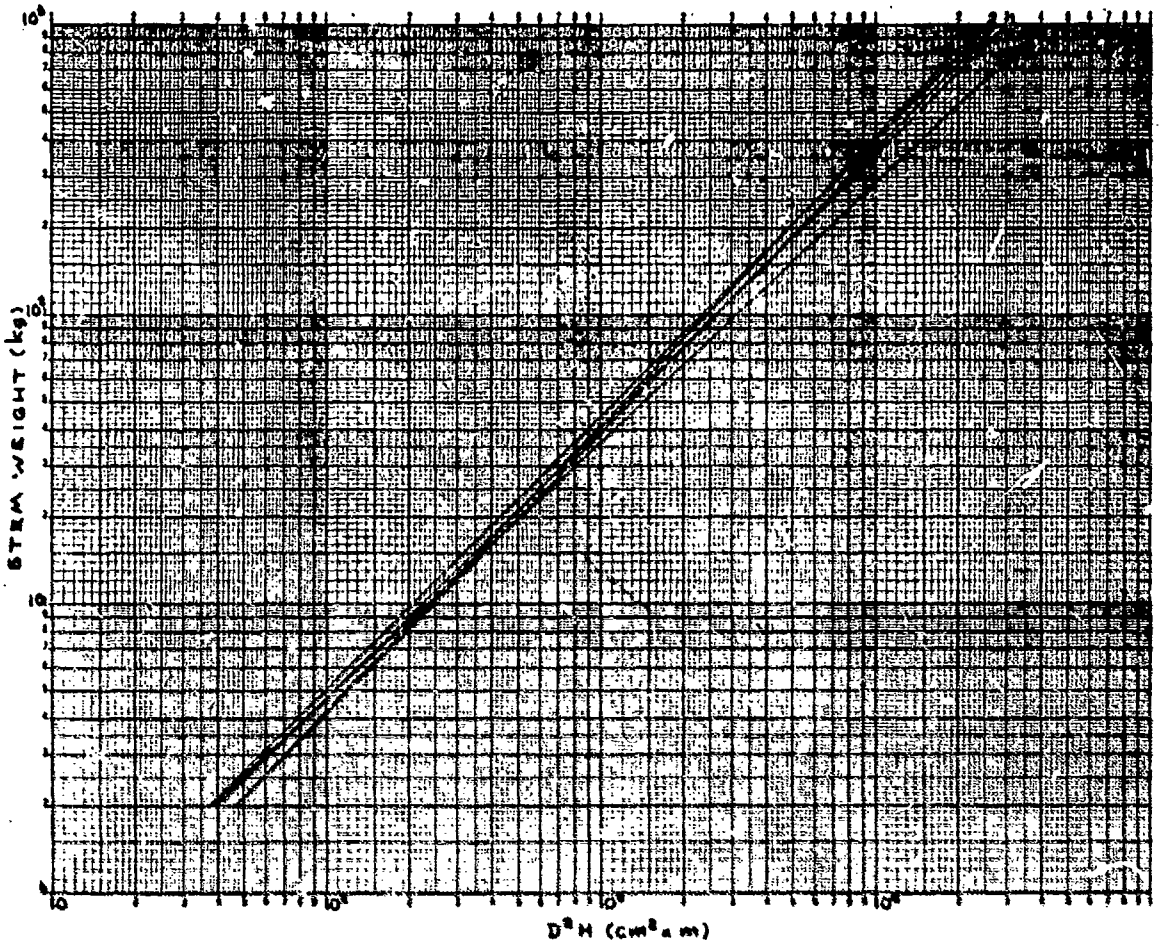

Figure 3. Allometric relation between dry stem weight and D^2H.

1 All species

$\log w_S = 0.93461 \log D^2H - 1.19984$

2 Hopea ferrea

$\log w_S = 0.93322 \log D^2H - 1.18289$

3 Hydnocarpus ilicifolius

$\log w_S = 0.88227 \log D^2H - 1.08465$

4 Walsura trichostemon

$\log w_S = 0.94300 \log D^2H - 1.17647$

5 Memecylon ovatum

$\log w_S = 0.98213 \log D^2H - 1.33776$

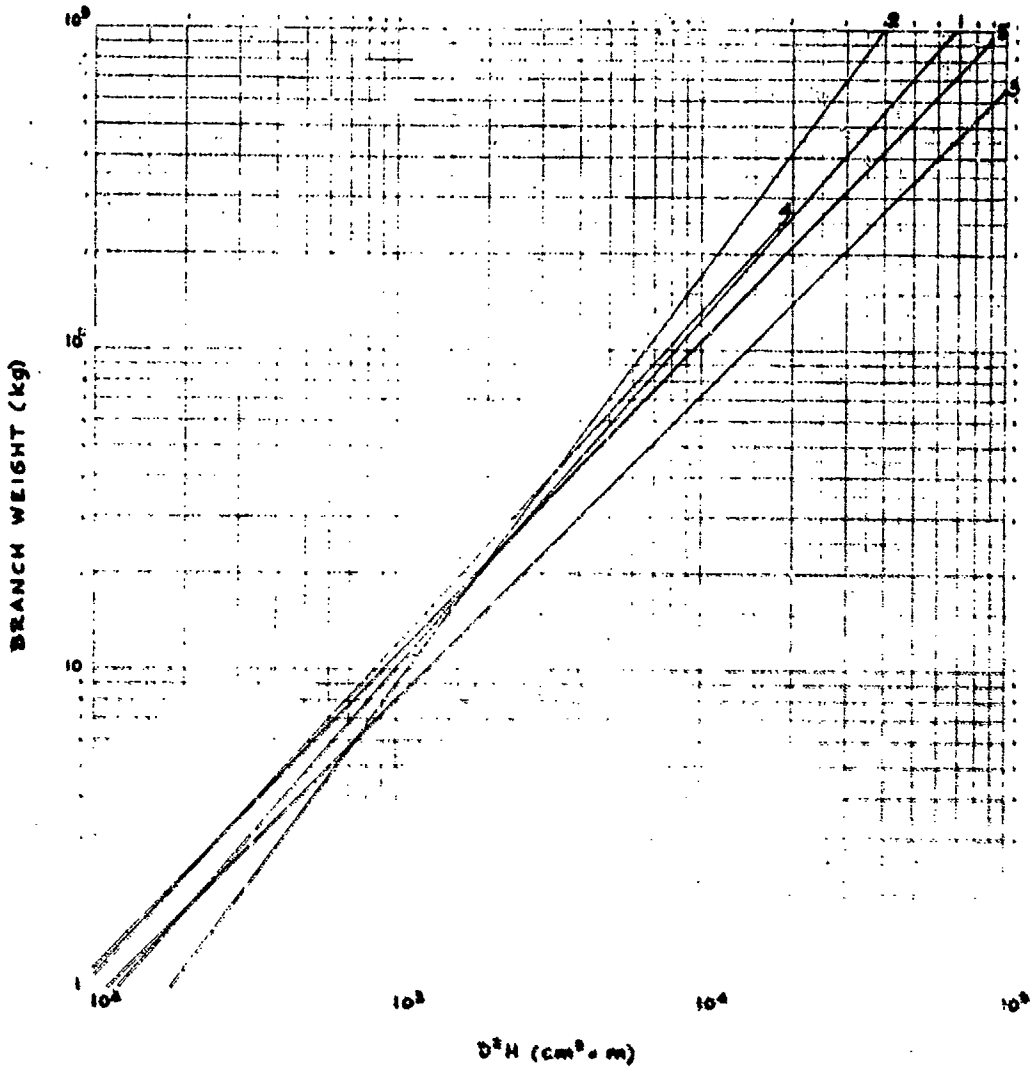

Figure 4. Allometric relation between dry branch weight and D^2H.

1 All species

$\log w_B = 1.09177 \log D^2H - 2.27676$

2 Hopea ferrea

$\log w_B = 1.26695 \log D^2H - 2.84233$

3 Hydnocarpus ilicifolius

$\log w_B = 0.95023 \log D^2H - 1.93983$

4 Walsura trichostemon

$\log w_B = 1.05623 \log D^2H - 2.08532$

5 Memecylon ovatum

$\log w_B = 1.00287 \log D^2H - 1.97380$

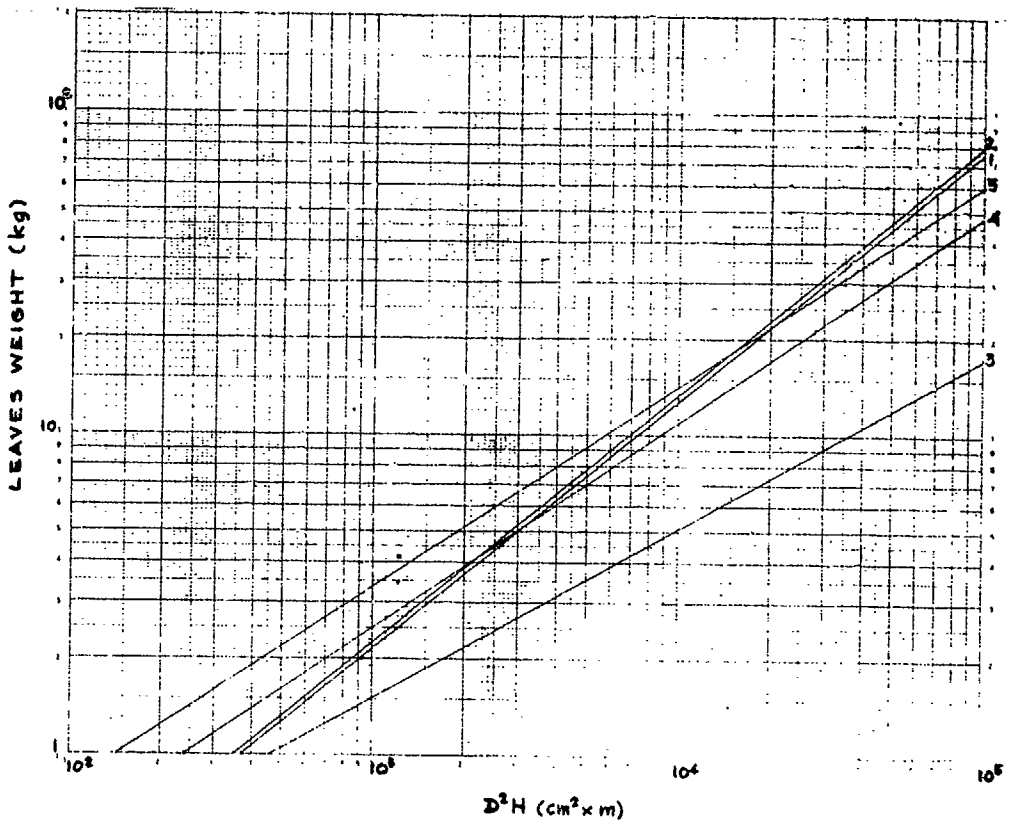

Figure 5. Allometric relation between dry leaves weight and D^2H.

1 All species

$\log w_L = 0.75614 \log D^2H - 1.91033$

2 Hopea ferrea

$\log w_L = 0.77223 \log D^2H - 1.96460$

3 ...ydnocarpus ilicifolius

$\log w_L = 0.51882 \log D^2H - 1.37536$

4 Walsura trichostemon

$\log w_L = 0.61606 \log D^2H - 1.43453$

5 Memecylon ovatum

$\log w_L = 0.63940 \log D^2H - 1.39836$

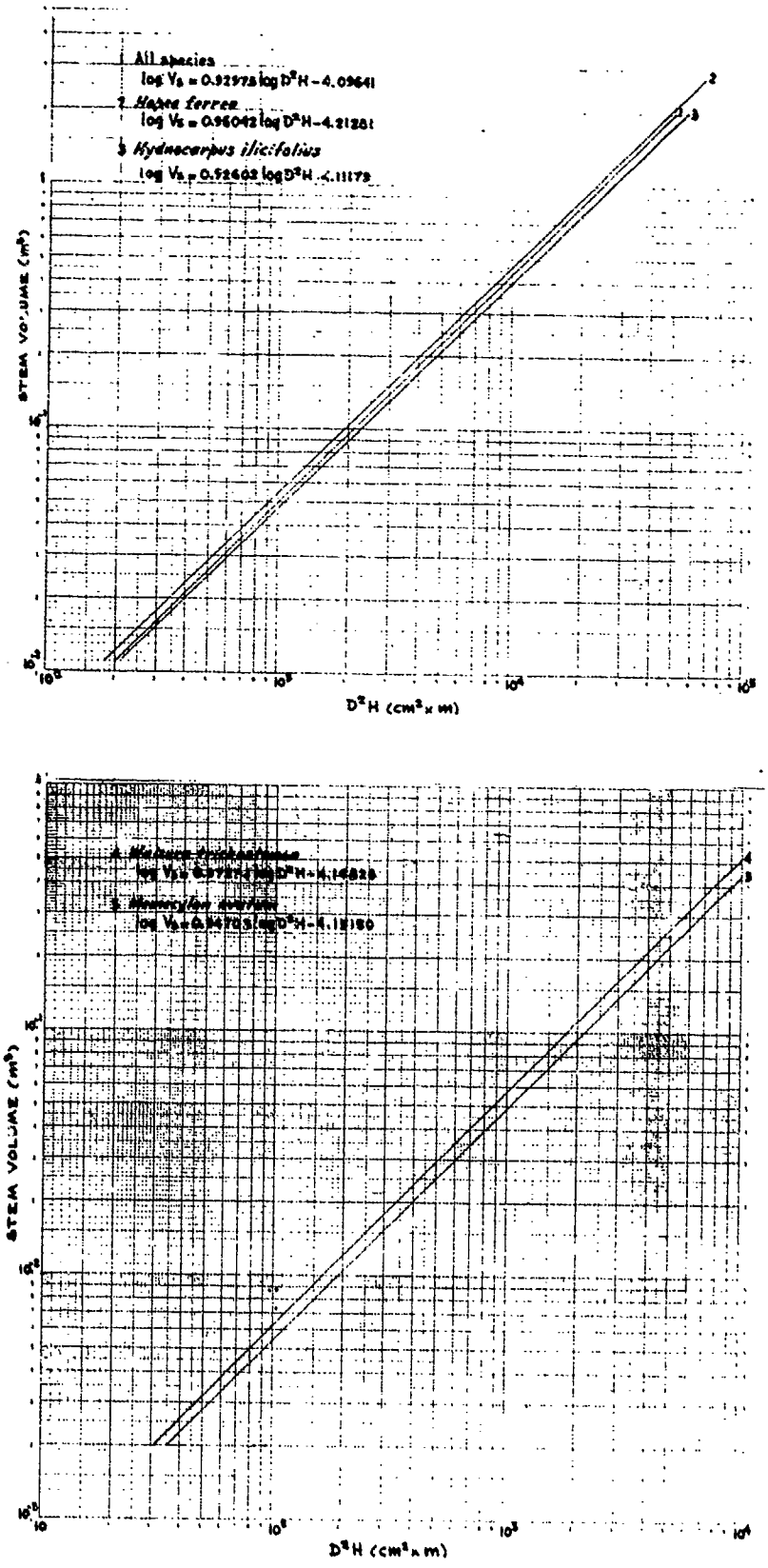

Figure 6. Allometric relation between stem volume and D^2H.

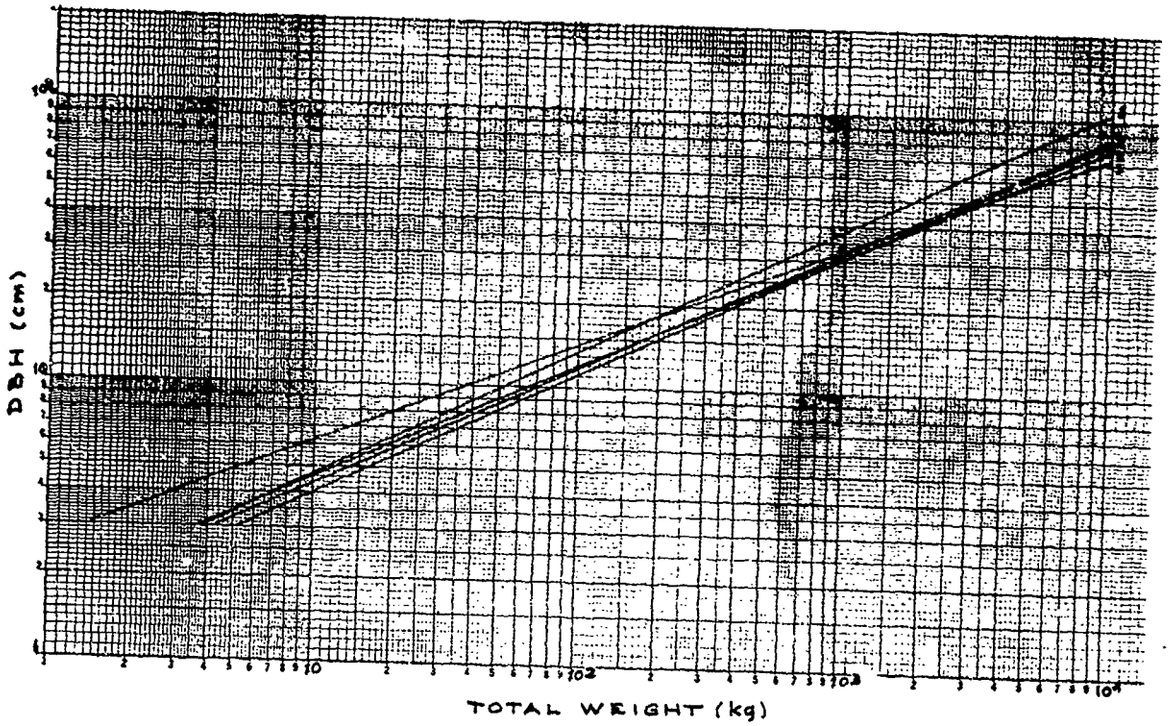

Figure 7. Allometric relation between total dry weight and DBH.

1 All species

$\log w_T = 2.37617 \log DBH - 0.58797$

2 Hopea ferrea

$\log w_T = 2.25891 \log DBH - 0.56600$

3 Hydnocarpus ilicifolius

$\log w_T = 2.17279 \log DBH - 0.45541$

4 Walsura trichostemon

$\log w_T = 2.52663 \log DBH - 0.67088$

5 Memecylon ovatum

$\log w_T = 2.73136 \log DBH - 1.14624$

TABLE 4

ALLOMETRIC RELATIONS BETWEEN D^2H AND WEIGHTS OR STEM VOLUME FOR ALL SPECIES

	W_T	w_T	w_S	w_B	w_L	V_S
h	0.95335	0.97309	0.93461	1.09172	0.75614	0.92973
log A	-0.94026	-1.17469	-1.19984	-2.27676	-1.91033	-4.09641
r	0.9143	0.9243	0.9270	0.8533	0.8390	0.9959
r^2	0.8359	0.8543	0.8593	0.7281	0.7039	0.9918

TABLE 5

ALLOMETRIC RELATIONS BETWEEN D^2H AND WEIGHTS OR STEM VOLUME FOR HOPEA FERREA

	W_T	w_T	w_S	w_B	w_L	V_S
h	0.96651	0.97644	0.93322	1.26695	0.77223	0.96042
log A	-0.99501	-1.20160	-1.18289	-2.84233	-1.96460	-4.21281
r	0.9917	0.8814	0.9290	0.8476	0.8559	0.9974
r^2	0.9835	0.7769	0.8630	0.7184	0.7326	0.9948

TABLE 6

ALLOMETRIC RELATIONS BETWEEN D^2H AND WEIGHTS OR STEM VOLUME FOR HYDNOCARPUS ILICIFOLIUS

	W_T	w_T	w_S	w_B	w_L	V_S
h	0.88054	0.88582	0.88227	0.95023	0.51882	0.92602
log A	-0.75799	-1.20959	-1.08465	-1.93983	-1.37536	-4.11179
r	0.9660	0.9810	0.9775	0.9793	0.9074	0.8041
r^2	0.9332	0.9624	0.9555	0.9590	0.8234	0.6466

TABLE 7

ALLOMETRIC RELATIONS BETWEEN D^2H AND WEIGHTS OR STEM VOLUME FOR WALSURA TRICHOSTEMON

	W_T	w_T	w_S	w_B	w_L	V_S
h	0.89202	0.93241	0.94300	1.05623	0.61606	0.97274
log A	-0.69231	-1.01555	-1.17647	-2.08532	-1.43453	-4.14826
r	0.9743	0.9875	0.9978	0.8734	0.6371	0.9942
r^2	0.9493	0.9752	0.9956	0.7628	0.4059	0.9884

TABLE 8

ALLOMETRIC RELATIONS BETWEEN D^2H AND WEIGHTS OR STEM VOLUME FOR MEMECYLON OVATUM

	W_T	w_T	w_S	w_B	w_L	V_S
h	0.95095	0.91463	0.98213	1.00287	0.63940	0.94703
log A	-0.92234	-1.22805	-1.33776	-1.97380	-1.39836	-4.15150
r	0.8007	0.8006	0.8011	0.7979	0.7696	0.9989
r^2	0.6411	0.6410	0.6418	0.6366	0.5923	0.9978

TABLE 9

ALLOMETRIC RELATIONS BETWEEN D AND w_T FOR FOUR MAJOR SPECIES AND ALL SPECIES

	Hopea ferrea	Hydnocarpus ilicifolius	Memecylon ovatum	Walsura trichostemon	All species
h	2.25891	2.17279	2.73136	2.52663	2.37617
log A	-0.36600	-0.45541	-1.14624	-0.67088	-0.58797
r	0.9530	0.9745	0.7584	0.9655	0.9627
r^2	0.9082	0.9497	0.5752	0.9322	0.9268

TABLE 10

SUMMARY OF DATA FOR THE 20M x 20M SAMPLE PLOT

Species	Green weight					Oven-dry weight					Stem volume (m^3)
	Stem (kg)	Branches (kg)	Leaves (kg)	Total (kg)	Total (tonnes/ha)	Stem (kg)	Branches (kg)	Leaves (kg)	Total (kg)	Total (tonnes/ha)	
Hopea ferrea	4653.70	2119.40	252.40	7025.50	175.64	3432.53	1220.03	131.37	4783.93	119.60	3.91586
Walsura trichostemon	634.60	130.70	51.40	826.70	20.67	461.88	84.44	22.85	568.47	14.21	0.55707
Memecylon ovatum	68.40	31.20	12.30	111.90	2.80	46.01	20.72	5.58	72.31	1.81	0.06356
Memecylon sp.	46.00	8.20	4.60	58.80	1.47	29.85	4.84	1.45	36.14	0.90	0.03262
Hydnocarpus ilicifolius	1816.70	617.30	61.00	2495.00	62.38	1149.98	366.06	23.30	1539.34	38.48	1.69775
Casearia grewiifolia	79.60	46.40	17.80	143.80	3.60	54.28	29.32	9.19	92.79	2.32	0.06664
Siphonodon celastrineus	522.30	83.30	27.20	632.80	15.82	334.27	52.81	11.67	398.75	9.97	0.41277
Aglaia sp.	226.00	63.00	9.40	263.30	6.58	169.95	40.70	4.39	215.04	5.38	0.17949
Melodorum sp.	77.10	20.90	6.70	104.70	2.62	52.43	12.46	3.27	68.16	1.70	0.07598
Shorea sericeiflora	217.00	9.20	2.80	229.00	5.73	149.08	5.28	1.77	156.13	3.90	0.20118
Unidentified	10.20	1.70	1.20	13.10	0.33	6.48	0.97	0.48	7.93	0.20	0.00751
Capparis micracantha	15.00	1.40	1.40	17.80	0.45	9.53	0.76	0.68	10.97	0.27	0.01409
Xerospermum intermedium	376.00	112.90	12.10	501.00	12.53	262.82	70.45	6.26	339.53	8.49	0.32137
Unidentified	192.50	9.10	4.20	205.80	5.15	97.60	5.66	2.07	105.33	2.63	0.14816
Total (trees and shrubs)	8935.10	3254.70	464.50	12629.20	315.73	6256.69	1914.50	224.33	8394.82	209.87	7.69405
Undergrowth	162.40		52.90	215.30	5.38	92.73		23.22	115.95	2.90	
Climbers	1767.10			1767.10	44.18	994.88			994.88	24.87	
Grand total				14611.60	365.29				9505.65	237.64	

TABLE 11

DATA OF TREES, CLIMBERS, AND UNDERGROWTHS IN A 20 M x 20 M SAMPLE PLOT

Tree no.	Actual D^2H	Species	DBH (cm)	Height (m)			Green weight (kg)				Oven-dry weight (kg)				Stem volume (m^3)
				First branch	Crown length	Total	Stem	Branches	Leaves	Total	Stem	Branches	Leaves	Total	
70	77.616	Hopea ferrea	4.20	2.00	2.40	4.40	6.20	1.40	1.30	8.90	4.23	0.84	0.61	5.68	0.00442
78	106.782	"	3.70	4.00	3.80	7.80	7.90	0.60	0.30	8.80	5.39	0.36	0.14	5.89	0.00495
107	144.648	"	4.20	6.00	2.20	8.20	13.30	3.00	2.50	18.80	9.07	1.80	1.17	12.04	0.00842
114	245.000	"	7.00	2.00	3.00	5.00	18.60	6.00	1.20	25.80	12.69	3.61	0.56	16.86	0.01520
106	324.900	"	5.70	6.00	4.00	10.00	21.70	2.50	2.10	26.30	14.80	1.50	0.98	17.28	0.01619
57	482.112	"	7.20	6.00	3.30	9.30	26.60	4.50	3.00	34.10	18.14	2.70	1.40	22.24	0.02185
116	573.300	"	7.00	7.00	4.70	11.70	29.80	4.90	2.20	36.90	20.32	2.94	1.03	24.29	0.02177
82	1113.336	"	9.40	8.00	4.60	12.60	55.80	14.00	3.90	73.70	39.06	9.04	1.81	49.91	0.04595
113	1224.120	"	10.10	6.00	6.00	12.00	65.40	18.30	6.10	89.80	45.78	11.82	2.82	60.42	0.04925
69	3472.265	"	13.70	8.00	10.50	18.50	190.40	36.10	10.50	237.00	133.28	23.32	4.86	161.46	0.17342
80	7927.065	"	20.70	12.00	6.50	18.50	453.60	198.50	21.80	673.90	336.57	113.74	11.53	461.84	0.43711
67	7927.588	"	21.50	6.00	11.15	17.15	376.90	184.50	22.50	583.90	279.66	105.72	11.90	397.28	0.31661
121	9132.032	"	22.40	8.00	10.20	18.20	497.80	223.90	48.00	769.70	369.37	128.29	25.39	523.05	0.44442
81	14981.964	"	27.10	12.00	8.40	20.40	762.30	199.90	33.80	996.00	565.63	114.54	17.88	698.05	0.62750
120	15053.850	"	27.00	6.00	14.65	20.65	678.70	671.20	43.60	1393.50	503.60	384.60	23.06	911.26	0.52999
124	25832.780	"	34.30	12.00	10.00	22.00	1448.70	550.10	49.60	2048.40	1074.94	315.21	26.23	1416.38	1.19881
		Total	-	-	-	-	4653.70	2119.40	252.40	7025.50	3432.53	1220.03	131.37	4783.93	3.91586
90	19.360	Walsura trichostemon	2.20	3.00	1.00	4.00	2.50	0.70	0.40	3.60	1.69	0.40	0.18	2.27	0.00144
110	26.250	"	2.50	3.00	1.20	4.20	2.20	0.20	0.30	2.70	1.49	0.11	0.14	1.74	0.00163

TABLE 11 (continued)

Tree no.	Actual D^2H	Species	DBH (cm)	Height (m)			Green weight (kg)				Oven-dry weight (kg)				Stem volume (m^3)
				First branch	Crown length	Total	Stem	Branches	Leaves	Total	Stem	Branches	Leaves	Total	
84	37.004	Walsura trichostemon	2.90	2.00	2.40	4.40	2.60	0.40	0.60	3.60	1.76	0.25	0.27	2.26	0.00240
105	75.950	"	3.50	4.00	2.20	6.20	5.10	0.50	0.50	6.10	3.45	0.28	0.23	3.96	0.00541
103	98.496	"	3.60	4.00	3.60	7.60	6.30	1.00	0.80	8.10	4.26	0.57	0.36	5.19	0.00574
87	133.308	"	4.60	4.00	2.30	6.30	8.50	0.40	0.30	9.20	5.75	0.23	0.14	6.12	0.00627
96	135.520	"	4.40	4.00	3.00	7.00	11.70	2.10	1.60	15.40	7.91	1.19	0.72	9.82	0.00768
112	152.421	"	4.70	4.00	2.90	6.90	8.90	2.00	1.20	12.10	6.02	1.14	0.54	7.00	0.00749
59	156.065	"	4.90	4.00	2.50	6.50	13.60	6.50	4.40	34.50	9.19	3.69	1.99	14.87	0.01469
72	158.976	"	4.80	4.00	2.90	6.90	9.90	2.70	1.30	13.90	6.69	1.53	0.59	8.81	0.00958
77	172.590	"	5.00	2.00	4.90	6.90	9.40	1.00	1.50	11.90	6.35	0.57	0.68	7.60	0.00987
95	212.500	"	5.00	1.30	7.20	8.50	15.70	5.80	0.40	21.90	10.61	3.29	0.18	14.08	0.01390
62	275.848	"	5.80	4.00	4.20	8.20	17.50	3.60	0.80	21.90	11.83	2.04	0.36	14.23	0.01395
111	288.923	"	5.90	4.00	4.30	8.30	16.50	3.70	1.50	21.70	11.15	2.10	0.68	13.93	0.01690
83	311.364	"	6.20	6.00	2.10	8.10	22.90	9.30	2.50	34.70	15.48	5.28	1.13	21.89	0.01645
115	335.872	"	6.40	4.00	4.20	8.20	19.30	7.60	3.00	29.90	13.05	4.32	1.36	18.73	0.01417
66	354.304	"	6.40	2.40	6.25	8.65	26.40	17.90	4.60	48.90	17.85	10.17	2.08	30.10	0.02073
86	473.854	"	7.10	6.00	3.40	9.40	25.90	3.90	2.90	32.70	17.51	2.22	1.31	21.04	0.02189
97	768.000	"	8.00	6.00	6.00	12.00	40.10	9.00	3.20	52.30	26.35	5.36	1.60	33.31	0.03317
54	1534.166	"	10.70	8.00	5.40	13.40	95.50	27.70	7.10	130.30	73.25	21.00	3.01	97.26	0.09438
55	1860.496	"	12.40	8.00	4.10	12.10	117.90	11.20	4.10	133.20	90.43	8.49	1.74	100.66	0.11338
99	2898.150	"	13.90	8.00	7.00	15.00	156.20	13.50	8.49	178.10	119.81	10.23	3.56	133.60	0.12595
		Total	-	-	-	-	634.60	130.70	51.40	826.70	461.88	84.44	22.85	568.47	0.55707

TABLE 11 (continued)

Tree no	Actual D^2H	Species	DBH (cm)	Height (m)			Green weight (kg)				Oven-dry weight (kg)				Stem volume (m^3)
				First branch	Crown length	Total	Stem	Branches	Leaves	Total	Stem	Branches	Leaves	Total	
68	45.648	Memecylon ovatum	3.10	1.60	3.15	4.75	3.30	0.60	0.40	4.30	2.22	0.40	0.18	2.80	0.00217
104	45.900	"	3.00	4.00	1.10	5.10	3.00	0.80	1.20	5.00	2.08	0.53	0.54	3.13	0.00443
60	68.600	"	3.50	4.00	1.60	5.60	4.50	0.60	0.80	5.90	3.02	0.40	0.36	3.78	0.00557
75	103.680	"	4.80	2.00	2.50	4.50	7.20	1.40	1.40	10.00	4.84	0.93	0.64	6.41	0.00645
73	200.096	"	5.20	4.00	3.40	7.40	12.80	0.80	2.20	15.80	8.60	0.53	1.00	10.13	0.01066
65	737.009	"	9.10	6.00	2.90	8.90	37.60	27.00	6.30	70.90	25.25	17.93	2.86	46.04	0.03628
		Total	-	-	-	-	68.40	31.20	12.30	111.90	46.01	20.72	5.58	72.31	0.06356
83	53.136	Memecylon sp.	3.60	2.00	2.10	4.10	5.00	2.20	1.90	9.10	3.25	1.30	0.60	5.15	0.00393
94	72.704	"	3.20	4.00	3.10	7.10	5.60	1.90	0.80	8.30	3.63	1.12	0.25	5.00	0.00444
76	622.080	"	7.20	6.00	6.00	12.00	35.40	4.10	1.90	41.40	22.97	2.42	0.60	25.99	0.02425
		Total	-	-	-	-	46.00	8.20	4.60	58.80	29.85	4.84	1.45	36.14	0.03262
92	28.556	Hydnocarpus ilicifolius	2.20	4.00	1.90	5.90	3.20	0.20	0.50	3.90	2.03	0.12	0.19	2.34	0.00253
119	1391.500	"	11.00	6.00	5.50	11.50	76.10	15.10	5.30	96.50	48.17	8.95	2.02	59.14	0.06679
123	8205.710	"	24.70	6.00	7.45	13.45	424.70	151.80	13.30	589.80	268.84	90.02	5.08	363.94	0.38585
118	10033.632	"	25.20	8.00	7.80	15.80	514.80	107.80	15.20	637.80	325.87	63.93	5.81	395.61	0.43845
122	28534.704	"	37.40	4.00	16.40	20.40	797.90	342.40	26.70	1167.00	505.07	203.04	10.20	718.31	0.83413
		Total	-	-	-	-	1816.70	617.30	61.00	2495.00	1149.98	366.06	23.30	1539.34	1.69775

TABLE 11 (continued)

Tree no.	Actual D^2H	Species	DBH (cm)	Height (m)			Green weight (kg)				Oven-dry weight (kg)				Stem volume (m^3)
				First branch	Crown length	Total	Stem	Branches	Leaves	Total	Stem	Branches	Leaves	Total	
74	33.408	Casearia grewiifolia	2.40	4.00	1.80	5.80	2.10	0.40	0.50	3.00	1.43	0.25	0.26	1.94	0.00222
89	96.000	"	4.00	5.00	1.00	6.00	6.40	2.20	0.80	9.40	4.36	1.39	0.41	6.16	0.00541
88	154.880	"	4.40	6.00	2.00	8.00	12.00	3.20	1.80	17.00	8.18	2.02	0.93	11.13	0.00860
63	1238.916	"	9.80	6.00	6.90	12.90	59.10	40.60	14.70	114.40	40.31	25.66	7.59	73.56	0.05041
		Total	-	-	-	-	79.60	46.40	17.80	143.80	54.28	29.32	9.19	92.79	0.06664
61	172.500	Siphonodon celastrineus	5.00	4.00	2.90	6.90	10.10	2.00	1.30	13.40	6.46	1.27	0.56	8.29	0.01043
85	1360.000	"	10.00	8.00	5.60	13.60	59.20	11.50	6.80	77.50	37.89	7.29	2.92	48.10	0.04997
117	9496.278	"	21.90	14.00	5.80	19.80	453.00	69.80	19.10	541.90	289.92	44.25	8.19	342.36	0.35237
		Total	-	-	-	-	522.30	83.30	27.20	632.80	334.27	52.81	11.67	398.75	0.41277
91	82.140	Aglaia sp.	3.70	2.00	4.00	6.00	6.90	1.70	0.80	9.40	5.19	1.10	0.37	6.66	0.00434
79	3773.172	" "	16.60	8.00	5.70	13.70	219.10	61.30	8.60	253.90	164.76	39.60	4.02	208.38	0.17515
		Total	-	-	-	-	226.00	63.00	9.40	263.30	169.95	40.70	4.39	215.04	0.17949
102	123.480	Meliodorum sp.	4.20	4.00	3.00	7.00	6.50	0.60	0.30	7.40	4.42	0.36	0.15	4.93	0.00563
58	1492.992	"	10.80	6.00	6.80	12.80	70.60	20.30	6.40	97.30	48.01	12.10	3.12	63.23	0.07035
		Total	-	-	-	-	77.10	20.90	6.70	104.70	52.43	12.46	3.27	68.16	0.07598

TABLE 11 (continued)

Tree no.	Actual D^2H	Species	DBH (cm)	Height (m)			Green weight (kg)				Oven-dry weight (kg)				Stem volume (m^3)
				First branch	Crown length	Total	Stem	Branches	Leaves	Total	Stem	Branches	Leaves	Total	
100	4147.200	Shorea sericeiflora	14.40	16.00	4.00	20.00	217.00	9.20	2.80	229.00	149.08	5.28	1.77	156.13	0.20118
64	152.776	Unidentified	5.20	4.00	1.65	5.65	10.20	1.70	1.20	15.10	6.48	0.97	0.48	7.93	0.00751
98	226.796	Unidentified	6.20	4.00	1.90	5.90	15.00	1.40	1.40	17.80	9.53	0.76	0.68	10.97	0.01409
109	6492.708	Xerospermum intermedium	20.60	10.00	5.30	15.30	376.00	112.90	12.10	501.00	262.02	70.45	6.26	339.53	0.32137
108	3240.032	Unidentified	14.60	10.00	5.20	15.20	192.50	9.10	4.20	205.80	97.60	5.66	2.07	105.33	0.14816
		Total	-	-	-	-	810.70	134.30	21.70	966.70	525.51	83.12	11.26	619.89	0.69231
Total (all trees)							8935.10	3254.70	464.50	12629.20	6256.69	1914.50	224.33	8394.82	7.69405
Undergrowth							162.40		52.90	215.30	92.73		23.22	115.95	
Climbers							1767.10			1767.10	994.88			994.88	

On the estimation of standing crops per unit area, past results showed a wide range of total weight among sample plots. Total weights (green) of standing crops collected from two sample plots in a nearby area as reported by Ogino et al. (1964) were 220.94 tonnes/ha and 403.77 tonnes/ha. Difference in total weight for such plots of the same size was believed due to the unusually big sized trees which happened to occur in one sample plot. Ogawa et al. (1965) reported a sum total of 291 tonnes/ha (oven-dry) for monsoon forest. Our attempt on the estimation of total weight per unit area is summarized in Table 9. The total green weight of trees, climbers, and undergrowth in a 20 m x 20m sample plot is 14,611.60 kg or 365.29 tonnes/ha, while the corresponding oven-dry weight is 9,505.65 kg or 237.64 tonnes/ha. The total green weight is between the figures given by Ogino et al. Such an estimate, therefore, may be taken as representative of forest production for this forest or for those of similar type.

VI. PROPOSALS FOR FURTHER WORK

The present study will be extended to include determination of root biomass in the near future. If a suitable kiln becomes available, additional large tree parts will be kiln dried and the results compared with those from the present technique of reducing green weights by oven-drying of samples. It is also intended to use the information on allometric relations to calculate biomass of the vegetation on a one hectare plot which has been surveyed in an associated study.

The work will be extended to provide other information needed for an estimate of primary productivity in this forest habitat.

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